

**Development and Implementation of Long-term Population Monitoring Using Genetic Tagging for
Fisher on the Hoopa Valley Indian Reservation, CA**

Final Report

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Abstract

Long-term demographic data on imperiled forest carnivores serve as a valuable metric for analyses such as quantifying the success or failure of re-introduction efforts, determining the effects of changes in forest management practices, and monitoring general population trends. However, the collection of these data can be time consuming and cost prohibitive. We developed an approach to collecting long-term demographic data for fisher by combining capture and marking efforts with remote digital photography, genetic marking, and passive integrated transponder (PIT) tag technology. We tested in both a captive and field setting incorporation of a passive integrated transponder (PIT) tag reader, a remote camera system, and a hair-snare into one device for use in long-term population monitoring. In the captive setting the PIT tag reader and digital camera system documented 52 and 51 of the 52 visits of the marked fisher, respectively. Unfortunately due to captive animal's behavior and hair snare design issues, we found the device to be ineffective in reliably collecting hair in the captive setting. The hair-snaring device has been redesigned and is currently being tested. In the field we successfully recorded 13 visits by fisher (10 marked, 3 unmarked). We determined the addition of a PIT tag reader into a genetic tagging mark-recapture approach has some cost-saving advantages. However, the comparatively high cost of PIT tag reading equipment may make the use of the technique cost-prohibitive over using a traditional mark-recapture approach using only trapping. We offer additional recommendations to managers considering developing a long-term population study.

Keywords: fisher, *Martes pennanti*, population monitoring, remote camera station, passive integrated transponder tag, PIT tag, hair snare, genetic marking, Hoopa Valley Reservation, northwest California.

The fisher (*Martes pennanti*) is a mid-sized, forest-dwelling, carnivore in the family Mustelidae. The U.S. Fish and Wildlife Service concluded the “distinct population segment” (DPS) of fishers historically occurring in the Pacific states to be warranted but precluded for listing under the Endangered Species Act (United States Fish and Wildlife Service 2004). However, localized population density of

fishers in some areas of northwestern California remained high, affording a unique opportunity to investigate poorly understood elements of fisher ecology in the Pacific states (Yaeger 2005, J.M. Higley, Hoopa Tribal Forestry, unpublished data).

Capture efforts as part of an ongoing fisher research project on the Hoopa Valley Reservation (hereafter reservation) in northwestern California yielded a 54% decline in capture success and an unexpected change in sex ratio compared to data collected on the reservation between 1996 and 1997 (Higley and Matthews 2006). This decline in capture success and change in sex ratio were strong indications that a population decline occurred between 1997 and 2005. Most alarming was that the decline seemed to be due primarily to declines in female numbers. However, a long-term population monitoring effort was not in place to more rigorously monitor this suspected population decline.

The benefit of developing an accurate, cost-effective, long-term population monitoring technique for fisher or any other at risk species is enormous. The value of these data has been demonstrated in the forests of the Pacific states through the conservation efforts involving the northern spotted owl (Anthony and Forsman 2005, Dugger et al. 2005). A similar need exists for fisher to collect long-term demographic data to measure the success or failure of re-introduction efforts, determine the effects of changes in forest management practices, and monitor general population trends.

Camera stations (Cutler and Swann 1999) and genetic analyses (Waits and Paetkau 2005) have been widely used as techniques to identify marked study animals in efforts to monitor general population trends. The potential for accurate population monitoring for fisher using these techniques is high because of the ease of capturing and re-sighting individual fisher. Non-juvenile recapture rates of 50% and re-sighting rates ranging from 63% to 73% using camera stations have been recorded on the reservation (J.M. Higley, Hoopa Tribal Forestry, unpublished data).

However, each of the above techniques has limitations. Ear tag retention for individual identification presents a problem when using remote camera stations as a method for long-term monitoring. Animals with missing tags are no longer identifiable individuals and could be mistaken for un-tagged individuals. Misidentification resulting from ear tag loss and ear tag deterioration after at least

one year of wear was 22% on the reservation (S.M. Matthews, Hoopa Tribal Forestry, unpublished data). An advantage of genetic tagging over traditional mark-recapture or mark-re-sight methods, particularly with fisher, is the elimination of the dependency of ear tag retention for individual identification. However, genetic analyses can become cost prohibitive, particularly when considering the number of genetic samples collected during a long-term population-monitoring effort (≥ 6 years).

Passive integrated transponder (PIT) tag technology has also been used as a method for monitoring long-term population trends (Gibbons and Andrews 2004). Use of PIT tags could serve as a means for more reliably identifying marked individuals and potentially reduce the cost of genetic analyses during a long-term population monitoring study. Misidentification during trapping efforts resulting from PIT tag loss or reading errors after at least 1 year of wear was 0% on the reservation (S.M. Matthews, Hoopa Tribal Forestry, unpublished data). We proposed a long-term population monitoring technique, which combined capture and marking efforts with digital passive infrared photography, genetic marking, and PIT tag technology to overcome failures to individually identify ear-tagged animals and the cost constraints of a mark-recapture design using only genetics to identify individuals. The combination of these tools for collecting accurate, long-term population data and reducing overall study costs could be advantageous to fisher conservation efforts range-wide.

Our proposed technique requires an intensive trapping effort to be conducted during the first year of the study to collect samples for age and genetic analyses, mark each captured animal with a PIT tag, and assess female reproductive status to develop reproduction indices (Frost et al. 1999). The capture effort would then be followed by 5 to 11 years of collecting resighting data using the remote devices. This effort would be combined with focused trapping efforts each year to mark previously unmarked animals identified by the remote devices and to assess annual rates of reproduction of previously marked females.

Long-term population monitoring should incorporate the collection of age data. For fisher, age data are most accurately collected using cementum annuli analysis of the first upper premolar (Strickland et al. 1982, Arthur et al. 1992). The genetic material collected from hair and/or tissue would be used to

develop population specific genetic markers and serve as the marked portion of the population. The PIT tag would be used to reduce the costs of genetic analyses by eliminating the need to submit all hair samples collected during the recapture effort for individual identification.

We proposed the use of a hair-snaring device equipped with a PIT tag reader and camera system. The camera would document with a date and time stamp the visit of a fisher and the PIT tag reader, also with a date and time stamp, would document if that fisher was marked or unmarked. These data would allow us to determine if the hair sample was from an unmarked animal and therefore would need to be submitted for genetic identification. Mixed hair samples would be avoided by using a hair-snaring device that would allow for collection of only one hair sample between checks by the researcher. Because fisher recapture rates are high, a large proportion of hair samples are typically from previously marked animals. Using genetic analyses would enable us to “mark” previously unmarked individuals and begin to build capture histories before that individual could be trapped and implanted with a PIT tag. Implementing this technique could significantly reduce the costs of genetic analyses over the duration of a long-term population monitoring effort using only genetic tagging.

The current study was undertaken to 1) test the incorporation of a passive integrated transponder (PIT) tag reader into a hair-snaring device to be used for long-term population monitoring, 2) implement the technique on a large section of the reservation, and 3) assess the cost-efficiency of these techniques for use in a long-term population monitoring effort.

Study Area

This study was conducted in a captive setting with one captive fisher at the Humboldt State University Game Pens Facility in Arcata, California and in a field setting on the reservation in northeastern Humboldt County, California (Figure 1). The reservation occupied approximately 362 km² and was bisected by the Trinity River in a south to north direction. Elevations ranged from 76 m to 1170 m. The landscape was a heterogeneous mix of habitats, dominated by Douglas fir (*Pseudotsuga menziesii*) and tanoak (*Lithocarpus densiflorus*). Most stands were classified as montane hardwood-conifer or Douglas fir (Mayer and Laudenslayer 1988). The reservation was not geographically isolated,

and the fisher population sampled was thought to be contiguous with the fisher population in northwestern California. The study was conducted on 53 km² and 78 km² portions of the reservation in the southeastern and northwestern quarters of the reservation, respectively.

Methods

Capture and handling methods were approved by the Institutional Animal Care and Use Committee of Humboldt State University, protocols 04/04.W.42.A and 05/06.W.44.A. Marking of fisher was conducted as part of an ongoing research project on the reservation (Higley and Matthews 2006). Anesthetized fishers were injected with a sterile 134.2 kHz passive integrated transponder (PIT tag, 134.2 kHz Super Tag, Sterile, Biomark, Inc., Boise, ID, USA). Uniquely colored plastic ear tags (Nasco Standard Rototag Blank, Nasco, Modesto, CA, USA) were placed in both ear pinnae for future identification. A first-upper premolar was removed for aging by cementum annuli (Matson's Laboratory, Milltown, Montana) (Strickland et al. 1982, Arthur et al. 1992, Poole et al. 1994). All fishers were released after recovery from anesthesia at their sites of capture.

Four multiple-element devices were constructed to test the feasibility of our proposed data collection techniques. Each device included three elements, a single sample hair snare (Figure 2), a PIT tag reader (model FS2001 ISO Reader and custom 45.72 cm interior diameter circular antenna, Biomark, Inc., Boise, ID; Figures 3, 4, and 5), and a digital, passive infrared triggered camera (model STC-WD3, Stealth Cam, Bedford, TX; Figures 3, 4 and 5). Each element was mounted inside a 45.7 cm interior diameter and 152 cm long corrugated, smooth-wall interior, polyethylene drainage pipe (model N-12, Advanced Drainage Systems, Inc, Hilliard, OH). The hair snare was a 1.27 cm thick plywood divider at the entrance of the device with an oval opening 8.5 cm high and 18 cm wide. A 25 cm long and 2 cm wide piece of steel strapping was mounted so it could be bent down in front of the oval opening. A 2 cm wide by 13.5 cm long piece of mouse and insect glue trap material (model 100 Series, AP&G Co., Brooklyn, NY) was duct taped to the steel strapping. When a fisher entered the device, it would enter through the oval opening, push against the bowed steel strapping causing the tension in the strapping to trigger the snare and the strapping to bend above the oval opening while collecting hair fixed to the glue

trap. The intent of the design was to reduce the likelihood of a mixed hair sample. Total equipment cost for 1 device was \$4,850 and required approximately 20 hours to construct once our design was finalized.

To test the functionality of each device we documented each visit by the captive fisher to the device at the HSU Game Pens Facility using a black and white, weatherproof night capable digital video camera (Extreme CCTV, Model EX26NX, Burnaby, British Columbia). The camera was connected to a motion sensitive digital video recorder (DVR; Seabyrd Technologies, Arcata, CA) using RG-59U 18/2 coaxial cable (Arrow Wire and Cable, City of Industry, CA) with BNC connectors. Cameras were powered using one 12 volt 32 amp hour absorbed glass matt battery. The DVR was plugged into a 110 volt power outlet. The battery and DVR were housed in a 55-gallon steel drum retro-fitted with a shelving unit to protect the equipment from weather. Each visit to the device recorded by the DVR was time and date stamped by the DVR. This allowed us to determine if each of the elements in the device also recorded the visit documented by the DVR.

Trials were conducted to determine if each of the three elements accurately recorded a visit of the captive fisher as documented on the DVR video. Effectiveness of the PIT tag reader and camera were determined by accurate documentation of each visit to the device where the captive fisher's shoulder passed into the device. Effectiveness of the hair snare was determined by the presence of a hair sample following a visit. Hair samples were also rated based on the number of hair follicles in the sample which is directly related to likelihood of a successful genetic analysis of the sample. Ratings were as follows: poor (1-3 follicles), fair (4-6 follicles), good (7-10 follicles), and excellent (>10 follicles). It should be noted that the number of visits to a station recorded by the hair snare will be lower than those recorded by the other devices because of the need to physically reset the hair snare between visits.

On the reservation, four locations were selected to test the efficiency of the devices in a field setting. These sites were selected based on past trapping experience throughout the study site in order to increase the likelihood of fisher visits. The DVR was not used in field. Rather, we simply compared visits recorded by either the hair snare, PIT tag reader, or camera independently and assessed if the other two elements also recorded a visit. Each station was run for 31 nights and checked every 2 to 3 days.

Finally, we conducted a cost-efficiency analyses considering the use of these techniques in a long-term population monitoring study. The primary emphasis was to determine if the use of the PIT tag reader would offset the genetic analyses expenses to make its use cost effective. A pilot study was conducted in March 2005 to collect data to assess the number a hair samples we might collect during a larger effort (S. M. Matthews and J. M. Higley, Hoopa Tribal Forestry, unpublished data). During the pilot study we employed static hair snaring devices using mouse and insect glue trap material on a rigid 1.27 cm piece of wooden doweling inserted into the entry way to a standard track plate box (Zielinski and Kucera 1995). Two additional pieces of doweling were used to block off enough of the entrance to ensure the animal would pass through the opening under the glue strip.

Results

The captive fisher in the HSU Game Pens Facility was recorded by the DVR entering the device on 52 occasions between 17 May and 14 June 2006. Unfortunately, due to the captive fisher consistently removing the glue strip of the hair snare with his teeth (a behavior we rarely observed in the field), we found the device to be ineffective in reliably collecting hair. The PIT tag reader accurately recorded each of the 52 visits. The digital camera took photographs on 51 of the 52 visits (98% of the visits). Of the 51 photographs, species could be identified in all 51 (98% of the visits), marked or unmarked status based on the presence of ear tags could be determined in 48 (92% of the visits), and individual identification could be determined in 43 (82% of the visits).

In the field trials, 13 visits of fisher (10 marked, 3 unmarked) were recorded by at least one element at the four devices between 5 March and 2 April 2006. The hair snare collected samples on 12 of the 13 visits (92%). Of the 12 samples, 8 (67%) were rated poor, 3 (25%) moderate, and 1 (8%) excellent. The PIT tag readers accurately recorded each of the 10 marked-fisher visits. The digital camera took photographs on all of the 13 visits. Of the 13 visits documented by the digital camera, species could be identified in all 13, marked or unmarked status could be determined in 11 (84% of the visits), and individual identification could be determined in 6 of the 10 marked-fisher visit (60% of the visits).

During the winter 2005 pilot study using 28 hair-snaring devices over a 14-day sampling period we collected 66 fisher hair samples. Each snare was checked every other day during the 14 days. Thus, we collected 0.337 hair samples per snare per check. We determined to effectively conduct a long-term population monitoring study across the entire reservation we would need 152 stations used over a 22-day sampling period. Based on our pilot study data, 564 hair samples would be collected annually. DNA extraction and genotyping using the necessary 10 genetic markers required for individual fisher identification for the Hoopa population has been estimated to cost \$75 per sample, resulting in a total cost of analyzing 564 samples to be \$42,300.

The purchase of 31 devices would allow for 152 sites to be surveyed for the 22-day sampling period over a 110 day field effort. The cost of the 31 devices at \$4,850 per device would be \$150,350 plus 20 hours of labor to construct each device. Based on remote camera mark-resight efforts conducted between 1997 and 2005, 22% of fishers visiting a camera station were unmarked. Thus, the use of the PIT tag reader in each device would reduce the number of hair samples requiring genetic identification collected annually from 564 to 124. Therefore, genetic analyses expenses drop from \$42,300 to \$9,300 with the use of a PIT tag reader used with each hair-snaring device.

We compared the cost-efficiency of collecting 6 years of demographic data using a mark-recapture design using only traps, a mark-resight design using only hair snares, and our proposed technique using an intensive trapping effort the first year followed by 5 years of resight data collection using remote devices supplemented with limited and focused trapping (Table 1). A mark-recapture design using only traps during the 110 day field effort would cost \$17,760 in personnel (assuming \$15/hr), \$2,600 in transportation, and \$10,000 in equipment for the first year. Equipment costs would be \$1,000 in subsequent years and other costs would remain the same. Thus, a 6 year effort would cost \$137,160.

A mark-resight design using only hair snares would require half the personnel and transportation costs, as hair snares would only be checked every other day rather than every day required of traps. Equipment costs would be similar to the mark-recapture effort, \$10,000 the first year and \$1,000

subsequent years. As calculated above, genetic analyses would cost \$42,300 annually. Thus, a 6 year effort would cost \$329,850.

Our proposed technique using an intensive trapping effort the first year followed by 5 years of resight data collection using remote devices and limited and focused trapping would require the same level of effort as the mark-recapture design above the first year and three quarters the effort in subsequent years. The three quarter estimate was based on checking remote devices every other day but occasionally needing to complete a focused trapping effort to mark previously unmarked animals, requiring checking traps every day when traps are in place. Thus, personnel and transportation costs would be \$17,760 and \$2,600 the first year and \$13,320 and \$1,950 in subsequent years, respectively. Equipment costs would be \$10,000 the first year during the trapping effort and \$160,650 for the materials (\$150,350) and labor (\$9,300) to construct the remote devices and equipment (\$1,000) for focused trapping. As calculated above, genetic analyses would cost \$9,300 annually. Thus a 6 year effort using our proposed methods would cost \$313,860.

Discussion

Remote camera, genetic analyses, and PIT tag technology provide significant opportunity for studying population trends over time for a large suite of imperiled species, including the fisher. We successfully tested the incorporation of a passive integrated transponder (PIT) tag reader and a remote camera system into a hair-snaring device intended for long-term population monitoring. Long-term population data could be used to measure the success or failure of re-introduction efforts, determine the effects of changes in forest management practices, and monitor general population trends. These data would have been especially insightful if they had been collected over the last 10 years on the reservation, during which we documented a 54% decline in capture success and an unexpected change in sex ratio of fisher, indicating a population decline.

Unfortunately in our current study the single sample hair snare did not prove effective. We attribute the failure in the HSU Game Pens Facility to the behavior of the captive fisher removing the glue strip from the metal strapping with his teeth, a behavior we rarely witnessed in the field. However, a

large percentage of the samples collected in the field were of poor quality and thus had a reduced likelihood of successful genetic analysis. During the pilot study 60.6 % of the samples collected were of fair or higher quality, thus improvements on the single sample hair snare device could likely be achieved. We are currently experimenting with an alternate design that has been used successfully with black bears (*Ursus americanus*) on the reservation. Results will be presented in a future manuscript on the technique.

The use of a PIT tag reading system working in concert with a hair-snaring device and remote camera system appears to have some cost-saving benefit, over hair-snare alone, in a long-term population monitoring study. However, the comparatively high cost of PIT tag reading equipment may make the use of the technique cost-prohibitive over using a traditional mark-recapture approach using only trapping. We would recommend the use of PIT tag reading equipment in a long-term population monitoring study if a manager has already committed to using a mark-resighting approach using genetic tagging, particularly if the cost of PIT tag reading equipment declines in the future. Additionally, this method would prove useful if a manager needs to address issues of invasiveness and trap avoidance in developing a monitoring approach. The assumption of equal sightability of marked and unmarked animals during the recapture effort can be problematic for studies using a mark-recapture approach using only traps (Minta and Mangel 1989). Using our proposed method which incorporated more than one capture method (traps used for the capture effort and multi-element devices used for the resighting effort) would contribute to meeting this assumption.

An alternative approach to our proposed method would be to remove the hair snare from the remote device and not collect genetic data. Thus, use only the remote camera to document the visit of a fisher and the PIT tag reader to assess marked status. This approach would not allow for the development of capture histories of unmarked animals using genetics prior to being PIT tagged. However, if a large proportion of the population was marked during the initial trapping effort, not marking these individuals prior to capture would not significantly impact model results (Lebreton et al. 2002). These devices could also be used to simultaneously monitor other mesocarnivores for relatively little additional cost, especially if genetic analyses are not used.

Both our proposed method and standard mark re-capture using trapping alone provide much more demographic data than the use of non-invasive genetic tagging alone. With capture and handling of animals we can accurately age individuals and with the use of reproductive indices such as those developed by Frost et al. (1999) we will likely be able to assess annual female reproductive rates. Lambda and survival estimates based solely on genetic identification may be biased significantly downward due to dispersal of juvenile fisher away from the study area. The collection of age data allows for the calculation of non-juvenile lambda and survival estimates, removing the potential bias of juvenile dispersal.

Management Implications

Developing a sound demographic monitoring program to be used long term similar to those used for spotted owls could be a powerful tool for the basis of future fisher and fisher habitat management decisions especially when planning for species recovery in areas of its range where it has been extirpated. PIT tag technology has exceptional promise as long-term marking technique for a host of forest carnivores, and does not appear to suffer from the limitations of many external marks. However, cost of PIT tag technology still remains prohibitively high for many managers, particularly in the context of a long-term population monitoring program requiring the purchase of several remote devices. Traditional mark-recapture continues to be the least expensive method of collecting long-term population data. However, if issues of invasiveness using traps or trap avoidance are of concern or a manager is developing a simultaneous monitoring program for a number of forest-carnivore species, we would recommend the use of this technique over traditional mark-recapture.

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Table 1. The cost-efficiency of collecting 6 years of demographic data using a mark-recapture design using only traps, a mark-resight design using only hair snares, and our proposed technique using a trapping effort the first year followed by 5 years of resight data collection using remote devices on the Hoopa Valley Indian Reservation, CA.

	Mark-recapture (traps only)	Mark-resight (hair snares only)	Proposed method (traps and remote devices)
Personnel	\$106,560	\$53,253	\$84,360
Transportation	\$15,600	\$7,800	\$12,350
Equipment	\$15,000	\$15,000	\$170,650
Genetic analyses	\$0	\$253,800	\$46,500
Totals	\$137,160	\$329,850	\$313,860



Figure 1. Map of Hoopa in Humboldt County, California.



Figure 2. Hair-snaring element mounted inside device at the Humboldt State University Game Pens Facility. When a fisher entered the device, it would enter through the oval opening, push against the bowed steel strapping causing the tension in the strapping to trigger the snare and the strapping to bend above the oval opening while collecting hair fixed to the glue trap. The intent of the design was to reduce the likelihood of a mixed hair sample.



Figure 3. Housing of passive integrated transponder (PIT) tag reader, digital camera, and batteries in back end of device developed for long-term population monitoring of fisher on the Hoopa Valley Reservation, CA.



Figure 4. Passive integrated transponder (PIT) tag reader and digital camera with housing extracted from main device for checking and servicing each element.



Figure 5. A view in the device with the hair snare removed to show the passive integrated transponder (PIT) tag reader antenna (white) and the digital camera mounted in the back.